National Environmental Research Program

LANDSCAPES & POLICY hub

The swift parrot nesting-habitat MCAS-S datapack from the Landscapes and Policy Hub

TUTORIAL

prepared by:

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2014

The Landscapes and Policy Research Hub is supported through funding from the Australian Government's National Environmental Research Program www.environment.gov.au/nerp and involves researchers from the University of Tasmania (UTAS), The Australian National University (ANU), Murdoch University, the Antarctic Climate & Ecosystems Cooperative Research Centre (ACE CRC), Griffith University and Charles Sturt University (CSU).

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The swift parrot nesting-habitat MCAS-S datapack & tutorial

Hub Publication Reference:

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Purpose of Document

The aim of this users' guide is to describe the spatial data in the datapack and provide instructions on how the layers can be analysed and explored in MCAS-S for decision support. The instructions take the form of a worked example. You will need to download and install MCAS-S software to your desktop or laptop. The worked example then steps you through using MCAS-S and how to open an MCAS-S package to combine layers. This guide is not intended to be a comprehensive guide to using MCAS-S. For more detailed information on how to use MCAS-S, including how to format spatial data for input to MCAS-S, please see the ABARES website – www.abares.gov.au/mcass and User Guide (ABARES 2014). The report is an output of the Landscapes and Policy Research Hub.

Please cite the document as follows:

Porfirio L, Carter L, Hugh S & Mackey B (2014) The swift parrot nesting-habitat MCAS-S datapack. Landscapes and Policy Hub, Hobart, Tasmania.

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Acknowledgements

The report is an output from the Landscapes and Policy Research Hub. The hub is supported through funding from the Australian Government's National Environmental Research Program and involves researchers from the University of Tasmania (UTAS), The Australian National University (ANU), Murdoch University, the Antarctic Climate and Ecosystems Cooperative Research Centre (ACE CRC), Griffith University and Charles Sturt University (CSU).

Table of Contents

1. Introduction to the swift parrot nesting-habitat MCAS-S datapack 6
   1.1. The swift parrot 6
   1.2. Climate change in Tasmania: direct and indirect threats 6
   1.3. The MCAS-S Tool 6
   1.4. The swift parrot nesting-habitat MCAS-S datapack and tutorial 7
2. Worked example background: Mapping potential refuges from predation and climate change for swift parrot nesting-habitat 9
   2.1. About the worked example 9
   2.2. Nesting-habitat for swift parrots: present and future threats 9
   2.3. Habitat suitability modelling 10
   2.4. Aim 11
   2.5. Data for the worked example 11
   2.6. Means-to-end diagram for current and future threats 14
   2.7. MCAS-S package structure 15
3. Worked example instructions 16
   3.1. Primary input data 16
   3.2. Composite data 17
   3.3. Modifying primary and composite data layers 23
   3.4. Overlays and masks 24
   3.5. Reporting 24
   3.6. Viewing results outside of MCAS-S 25
   3.7. Management conclusions from the worked example 26
4. Appendix 27
5. References 28

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Glossary	
ABARES	Australian Bureau of Agriculture and Resource Economics and Sciences
ALA	Atlas of Living Australia
ANN	Artificial neural networks, used in BIOMOD forecasting
ArcGIS	Software produced by ESRI that enables spatial data to be generated, analysed, manipulated, stored and managed
BIOMOD	BIOMOD is a computer platform for ensemble forecasting of species distributions, enabling the treatment of a range of methodological uncertainties in models and the examination of species-environment relationships.
Composite data layer in MCAS-S	Any layer that combines data from more than one layer
CTA	Classification tree analysis, used in BIOMOD forecasting
Current climate	Baseline climate surfaces (1976–2005) used in BIOMOD to obtain the habitat suitability maps for the species.
FPA	Forest Practices Authority Tasmania
Future climate	Future climate projections for the period 2070–2099, under the A2 emissions scenario, based on the output of three dynamically downscaled climate models (UKMO-HadCM3, GFDL-CM2.0 and MIROC3.2 (medres)). Used in BIOMOD to obtain the future habitat suitability maps for the species.
GAM	Generalized additive regression model, used in BIOMOD forecasting
GBM	Gradient boosting machines, used in BIOMOD forecasting
GCM	Global Climate Models used to project the future climate
GIS	Geographic Information Systems are tools used to capture, store, manipulate, analyse and manage spatial data
GLM	Generalized linear regression model, used in BIOMOD forecasting
Habitat suitability	The ability of an area to support the survival and reproduction of a focal species. Our models calculate suitability of a pixel based on climate information, also known as the climatic envelope for a given species.
IBRA	Interim Biogeographic Regionalisation for Australia, undertaken by the federal Department of the Environment
Information Panel	Left-hand panel in MCAS-S used to edit maps
Input layer	Data layer contained within the primary folder of an MCAS-S project
LaP	Landscapes and Policy Hub
Mask	A type of data layer used in MCAS-S to restrict analyses to a defined area
Mature forest	Mature or old growth forest is characterised by a forest that has attained great age without significant disturbance and thereby exhibits unique ecological features. Mature forests present a diverse and complex structure, characterised by a multi-layered canopy, tree heights and diameters.
MCAS-S	The Multi-Criteria Analysis Shell for Spatial Decision Support is a decision support tool designed specifically for non-GIS users to integrate spatial data

Glossary continued	
MCAS-S datapack	A series of folders and data layers organised and formatted ready for use in an MCAS-S project
MDA	Mixture discriminant analysis, used in BIOMOD forecasting
Model agreement	A technique used to summarise the output of multiple habitat suitability models, in which the pixels where ALL models predicted suitable are shown on the map
Multi-way map	A composite map layer created using the multi-way function to combine more than two input layers
NERP	National Environmental Research Program, funded by the Australian Government
Overlay	A data layer used in MCAS-S as a visual reference, which does not influence any calculations occurring in composite maps
P4	Project 4 within LaP, also known as the Bioregional Futures Project
RF	Random forest, used in BIOMOD forecasting
Tip file	A short metadata record used to describe data layers exported from MCAS-S
Two-way map	A composite map layer created using the two-way function to combine two input layers
Viewer window	A pop-up window within in MCAS-S that shows the value of a pixel in a map plus values of all input layers to that map upon mouse hover over the pixel of interest. The viewer opens by default but if closed can be opened via the Edit tab.

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1. Introduction to the swift parrot nesting-habitat MCAS-S datapack

1.1. The swift parrot

The swift parrot (*Lathamus discolour*) is an Australian nectarivorous bird that is listed as endangered under the Tasmanian *Threatened Species Protection Act 1995* and endangered on the Commonwealth's *Environment Protection and Biodiversity Conservation Act 1999*. It has a regular annual migration pattern, with the entire population migrating from south-eastern Australia to Tasmania from September to March, as Tasmania is the only location where the species breed. The nesting habitat is characterised by a very specific type of tree hollow only found in the mature forests of Tasmania, mostly Blue gums (*Eucalyptus globulus*), which also provides a food resource during the breeding season. Swift parrots are threatened by broad-scale habitat loss (Mac Nally and Horrocks 2000), which is likely to interact with other threatening processes such as heightened predation. The Tasmanian breeding range of swift parrots is also under ongoing pressure from habitat loss (Saunders and Tzaros 2011) and it may be impacted by future climate projections. A management priority in Tasmania is to detect areas for conservation to secure nesting-habitat resources for the species in the long term. However there are knowledge gaps in the species ecology (Forest_Practices_Authority 2010) which adds further complexity to the issue.

1.2. Climate change in Tasmania: direct and indirect threats

Climate projections from the Climate Futures for Tasmania project suggest that temperatures will rise by about 2.9°C by the end of the century, based on the high CO_2 emissions scenario (SRES A1), which triggers a decrease in cloud cover and an increase in evaporation (Grose et al. 2010). The Climate Futures for Tasmania also projected great changes in seasonal rainfall patterns, with increased rainfall over coastal regions and reduced rainfall over central Tasmania and the north-west (Grose et al. 2010). However, the frequency of extreme events, like high temperatures and strong winds, is projected to increase, which will increase the risk of bushfires (Grose et al. 2010).

1.3. The MCAS-S Tool

The Multi-Criteria Analysis Shell for Spatial Decision Support (MCAS-S), developed by Dr Rob Lesslie and colleagues at the Australian Bureau of Agricultural and Resource Economics and Sciences (Lesslie et al. 2008), is a decision support tool designed specifically for non-GIS users to easily explore spatial data and apply them to natural resource management and planning problems.

The tool is free and users require little training to analyse spatial data and assess the results. MCAS-S allows people with different levels of technical and scientific expertise to easily and interactively interrogate and analyse spatial data, answer 'what if' questions, and build scenarios

that map the implications of different conservation management interventions. MCAS-S has the potential to be a very useful tool for ecological management because a range of spatial data can be easily integrated to explore potential futures or the effects of management decisions, particularly in workshop situations when data may be incomplete and decision-making is by consensus. Here we show how this tool can be used to visualise and explore spatial variability in threats and opportunities for conservation of the nesting-habitat of swift parrots in Tasmania.

1.4. The swift parrot nesting-habitat MCAS-S datapack and tutorial

This users' guide and data package includes an MCAS-S datapack which contains spatial data for identifying swift parrot nesting-habitat at risk in Tasmania, plus supporting data layers such as the reserve estate and biogeographic regions. The MCAS-S approach allows managers to pinpoint areas that are least-threatened and therefore may act as refuge or sanctuary from predation and future changes in climate. The datapack does not provide recommendations or an answer as to what management activities should occur. Rather we provide the data for further exploration of the issues using MCAS-S. The datapack consists of MCAS-S formatted spatial data and sample MCAS-S project files that illustrate how the data can be combined to support decision-making. Further data could be added by users as it becomes available.

The aim of this tutorial is to describe the spatial data in the datapack and provide instructions on how the layers can be analysed and explored in MCAS-S for decision support. The instructions take the form of a worked example. You will need to download and install MCAS-S software to your desktop or laptop. The worked example then steps you through using MCAS-S and how to open an MCAS-S package to combine layers. This tutorial is not intended to be a comprehensive guide to using MCAS-S. For more detailed information on how to use MCAS-S, including how to format spatial data for input to MCAS-S, please see the ABARES website – www.abares.gov.au/mcass and User Guide (MCAS-S development partnership 2014).

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Installing MCAS-S Software

To use the datapack, you need to download and install the free MCAS-S software (ABARES 2014) onto your Windows computer.

1. Go to MCAS-S home page: www.abares.gov.au/mcass
2. Go to the right-hand side menu and click on **MCAS-S Tool**
3. A new page opens with two download options –
   a. MCAS-S Version 3.1 installer (150MB) – takes about 10mins
   b. MCAS-S Version 3.1 user guide (10MB)
4. Download the installer (arrives zipped) then unzip – takes about 10mins. If you are new to MCAS-S, also download the MCAS-S user guide.
5. Once downloaded, follow prompts to install (requires 'Quicktime' to also be installed)
6. Register as a user

Unzip the MCAS-S Datapack

Before you start playing with our worked example, the next step is to extract the datapack from its zipped folder (right-click and unzip to you). If the datapack isn't unzipped correctly, MCAS-S will not be able to upload the spatial data and a red cross will appear in each map box instead of a map.

Now you are right to go!

2. Worked example background: Mapping potential refuges from predation and climate change for swift parrot nesting-habitat

2.1. About the worked example

This worked example guides you through how you might use MCAS-S to consider a query for mapping potential refuges from predation and climate change for swift-parrot nesting habitat, which occur only in Tasmania. We provide background information about the issue, sketch out the essential 'means-to-end' diagram, and then take you through a data combining exercise.

2.2. Nesting-habitat for swift parrots: present and future threats

Suitable nesting-habitat for swift parrots requires the presence of mature forests with hollows for nesting, and flowering Eucalypts (mostly *E. globulus* but also *E. ovata*) as food resources (Forest_Practices_Authority 2010). These breeding habitat resources are scattered mainly along the East coast of Tasmania (Figure 1).

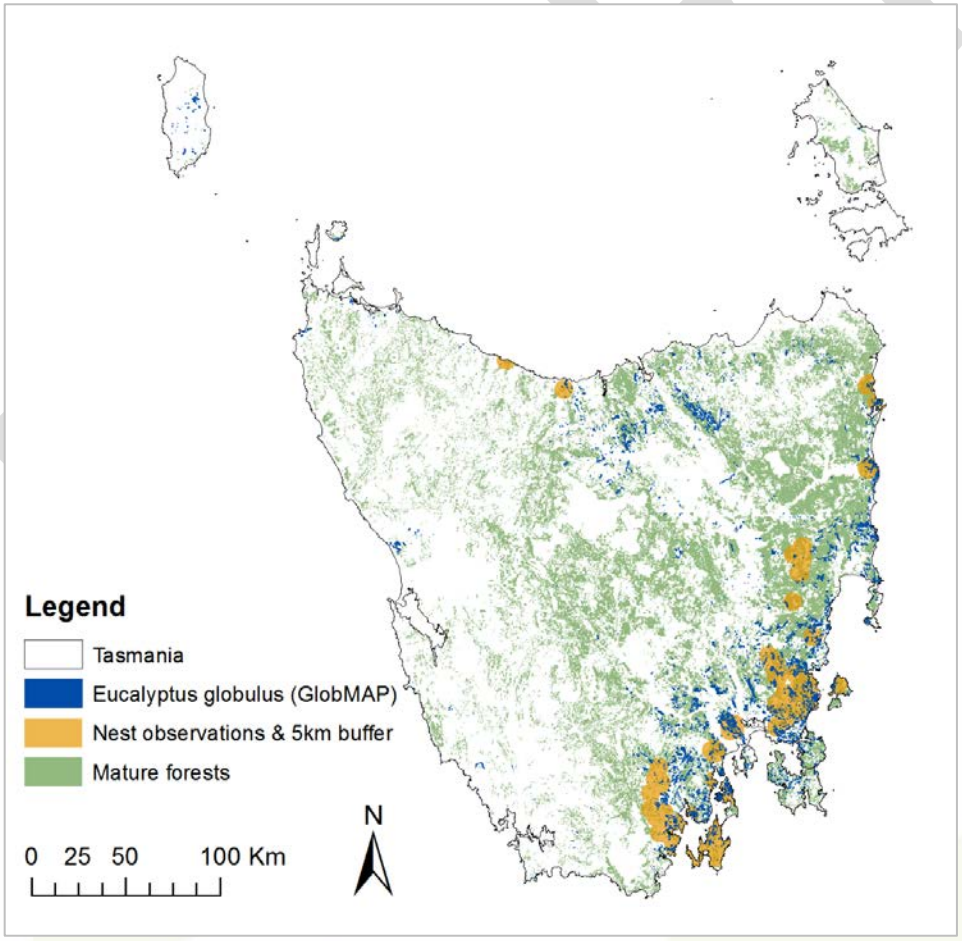

Figure 1: Nesting-habitat for the swift parrot. *Eucalyptus globulus* distribution from GlobMap, nest observations from Stojanovic et al (2014), mature forest data from Forest Practices Authority.

Food availability is a major driver in the location of nests for a given year and as Blue gums (*E. globulus*) present a very irregular flowering pattern (Webb et al. 2014), it makes management of nesting-habitat a challenging task. Over the period 2010–2012, nesting sites were geo-located and information about the habitat collected to assess breeding success or failure (Stojanovic et al. 2014). Their results showed that a major threat to swift parrots is predation by sugar gliders (*Petaurus breviceps*). Predation risk varied dramatically across the breeding range, depending on the presence of sugar gliders. One of the main conclusions of Stojanovic et al. (2014) is that offshore islands are an important refuge for swift parrots because sugar gliders are absent.

2.3. Habitat suitability modelling

To test whether or not climate change would affect swift parrot nesting-habitat, we developed models of habitat suitability using future climate projections and testing for change by the period 2070-2100, centred in 2080 (hereafter 2080 or end of the century). We repeated the procedure to test for sugar glider's habitat suitability and the two Eucalypts that provide food and hollows for nesting (habitat resources). As sugar glider's proved to be a major threat to swift parrots, we wanted to know to what extent glider's habitat would co-occur with swift parrots' by the end of the century. We also included the projected future forest fire danger index (FFDI) as a threat to consider the impact of climate change upon the likelihood of fire damage to swift-parrot nesting hollows.

Habitat suitability for all species was modelled using BIOMOD in the 'biomod2' package (Thuiller et al. 2009) using R software. BIOMOD generates ensemble forecasting maps based on ten statistical models, including regression (GLM, GAM) and classification (CTA, MDA) methods, maximum entropy (Maxent), flexible discriminant analysis (FDA), machine learning techniques (ANN, RF, GBM) and surface range envelope (SRE) .

We use consensus scenarios for the species by utilising climate data for two time periods: 1976–2005 (hereafter the baseline period) and 2080, under the A2 emissions scenario. The modelling techniques in BIOMOD assume that the inputs represent presence and absence of the species. In this study we used presence only data, and randomly generated pseudo-absences in BIOMOD for each species. We used 70% of the data to run the ensemble forecasting and the remaining 30% was used to run evaluation models. Models were evaluated with a relative operating characteristic (ROC). The bioclimatic variables used in BIOMOD were selected using principal component analysis (PCA) to select uncorrelated variables ($R^2 < 0.6$) that accounted for more than 95% of the variance. We present the ensemble SDMs as binary maps of climate suitability, using a threshold value of 0.5 (Phillips & Dudik 2008).

2.4. Aim

The MCAS-S datapack can be used to identify locations that could act as refuges for swift parrots in Tasmania by integrating spatial data on the location of landscape features that may influence the availability of habitat resources during the breeding season.

The types of spatial data considered for the analysis included habitat suitability maps based on current and future climate projections, mature forest extent, the forest fire danger index (FFDI) and forest loss and gain during 2000-2012. Forest loss and gain are considered a threat to swift parrots because both represent loss of mature forests. Forest gain mainly highlights forests converted to plantations or those recovering from being dramatically burnt, which are unlikely to provide habitat resources for nesting. Data on land tenure/protection and nest observations are also included for the purpose of prioritising refuges or for reporting.

2.5. Data for the worked example

A complete list of data layers available for this analysis is shown in Table 1. The data are grouped into five types:

1. Current habitat resources: potential areas where swift parrots breeding may succeed (as observed by Stojanovic et al. 2014)
2. Current threats: potential areas where swift parrots breeding would not succeed
3. Future habitat resources: potential areas where swift parrots breeding may succeed
4. Future threats: potential areas where swift parrots breeding would not succeed
5. Supporting data

The types of spatial data considered for the analysis included vector and raster data. MCAS-S requires all data for analysis to be in raster format so other data types (vector, point and polygon) were converted (eg rasterised). Species data invariably comes in the form of point locations where an animal has been sighted during a particular survey (Stojanovic et al. 2014). Prior to conversion, data observation points for individual species were buffered by 5 km to account for species movement (if needed, other relevant buffering distances could be calculated using the raw point data directly in MCAS-S).

Data values in this worked example are in binary format. Values of '1' were given to grid cells that meet the criteria, for example presence of nesting-habitat resources. 'NoData' values were used for grid cells that do not meet the criteria. Justification for each criterion are provided in Table 1.

Table 1: Primary input layers available for swift parrot nesting-habitat analysis

Data layer	Type	Source	Description	Criteria	Justification
Swift parrot current nesting-habitat	Current habitat resources	Bioregional futures and Climate futures, NERP LaP	BIOMOD output. Areas predicted to be climatically suitable for the species based on nesting observation data.	Probability values above 50% were considered suitable	Phillips and Dudík (2008)
Swift parrot future nesting-habitat 2080	Future habitat resources	Bioregional futures and Climate futures, NERP LaP	BIOMOD outputs summarised using model agreement technique. Areas projected to be climatically suitable by 2080 for the species based on current nesting observation data.	Probability values above 50% were considered suitable. We used climate data from 3 GCMs that were summarised in one map using model agreement techniques.	Model agreement was the models 'summary' technique where pixels in which all models predict values above 50% are displayed. This technique was chosen by land managers from the Department of the Environment after a meeting in 2013.
Sugar glider current suitable habitat	Current threat	Bioregional futures and Climate futures, NERP LaP	BIOMOD output. Areas predicted to be climatically suitable for the species based on nesting observation data.	Probability values above 50% were considered suitable	Phillips and Dudík (2008)
Sugar glider future suitable habitat 2080	Future threat	Bioregional futures and Climate futures, NERP LaP	BIOMOD outputs summarised using model agreement technique. Areas projected to be climatically suitable by 2080 for the species based on current nesting observation data.	Probability values above 50% were considered suitable. We used climate data from 3 GCMs that were summarised in one map using model agreement techniques.	Model agreement was the models 'summary' technique where pixels in which all models predict values above 50% are displayed. This technique was chosen by land managers from the Department of the Environment after a meeting in 2013.
***E. globulus* current suitable habitat**	Current habitat resources	Bioregional futures and Climate futures, NERP LaP	BIOMOD output. Areas predicted to be climatically suitable for the species based on observation data obtained from ALA.	Probability values above 50% were considered suitable	Phillips and Dudík (2008)
***E. globulus* future suitable habitat**	Future habitat resources	Bioregional futures and Climate futures, NERP LaP	BIOMOD output. Areas predicted to be climatically suitable for the species based on observation data obtained from ALA.	Probability values above 50% were considered suitable. We used climate data from 3 GCMs that were summarised in one map using model agreement techniques.	Phillips and Dudík (2008)
***E. ovata* current suitable habitat**	Current habitat resources	Bioregional futures and Climate futures, NERP LaP	BIOMOD output. Areas predicted to be climatically suitable for the species based on observation data obtained from ALA.	Probability values above 50% were considered suitable	Phillips and Dudík (2008)
***E. ovata* futuret suitable habitat**	Future habitat resources	Bioregional futures and Climate futures, NERP LaP	BIOMOD output. Areas predicted to be climatically suitable for the species based on observation data obtained from ALA.	Probability values above 50% were considered suitable. We used climate data from 3 GCMs that were summarised in one map using model agreement techniques	Phillips and Dudík (2008)
GlobMap	Current and future habitat resources	DPIPWE (DPIPWE 2010)	The Swift Parrot Foraging Habitat Map. GlobMap is the compilation of targeted species mapping and the pre-existing TASVEG. It is a more accurate map with a wider coverage of breeding season foraging habitat for swift parrots.	http://dpipwe.tas.gov.au/Pages/document.aspx?path=/Documents/GlobMap.pdf	Relevant vegetation information

Nest observations & 5km buffer	Current and future habitat resources	Dejan Stojanovic	Field work data, buffered by a 5km radius		Stovanovic et al. (2014)
Forest loss	Current threat	NASA	Global Forest Change 2000–2012 based on Landsat satellite data	http://earthenginepartners.appspot.com/science-2013-global-forest (Hansen et al. 2013)	Forest loss is a major threat for swift parrot nesting-habitat
Forest gain	Future habitat resources	NASA	Global Forest Change 2000–2012 based on Landsat satellite data	http://earthenginepartners.appspot.com/science-2013-global-forest (Hansen et al. 2013)	Forest gain may represent an opportunity for swift parrot nesting-habitat in the future
Fire frequency	Current threat	Data processed by Bioregional futures NERP LaP, monthly satellite data obtained from Vegetation and Fire project NERP LaP, satellite data downloaded from AusCover portal	Fire frequency for the period 2000-2012 based on MODIS satellite data, MCD64A1 product (NASA)	The combined use of active-fire and reflectance data enables the algorithm to adapt regionally over a wide range of pre- and post-burn conditions and across multiple ecosystems. Text from Giglio et al. (2009) http://dx.doi.org/10.1016/j.rse.2008.10.006	Depending on its intensity, fire can cause damage to mature forest's structure, reducing the availability of nesting-habitat
FFDI (future projection 2081-2100)	Future threat	Climate futures, NERP LaP	The McArthur Forest Fire Danger Index indicates the degree of fire danger in Australian forests as a function of climatic variables including rainfall, wind speed, temperature & humidity.	Classes extreme, severe and very high, used to mask future suitable habitat for the focal species.	Future climate change is projected to alter fire regimes, with an increase in fire danger & changed seasonality of fires which may impact Swift parrot habitat. (Fox-Hughes et al. 2014)
Mature forests	Current habitat resources	Modified layer, originally from www.fpa.tas.gov.au	Current extent of mature forests was produced by reclassifying Forest Practices Authority data into a binary file of mature or non-mature forests	Dataset not included as it was provided by the FPA under licence.	Mature forests provide food and nesting habitat resources
Mature forests & Globmap	Current habitat resources	Globmap data & FPA Mature forests data	Globmap data buffered by 10km to inclue areas just outside foraging habitat. Intersected with mature forests to highlight potential mature nesting-habitat		FPA (2010) notes the Eastern breeding range was buffered by 10km to include areas of mature forest just outside the foraging habitat.
Privately and publicly managed reserves	Current and future habitat resources & supporting data	DPIPWE http://dpipwe.tas.gov.au/conservation/development-planning-conservation-assessment/tools/tasmanian-reserve-estate-spatial-layer	This layer provides a spatial representation of Tasmania's Reserve Estate for use as the authoritative source of information on the extent, type and distribution of the comprehensive, adequate and representative (CAR) reserve system in Tasmania.	We focus on the co-occurrence of reserves and suitable nesting habitat	Areas that are projected to be suitable and are under a private or public reserve system provide an opportunity for management
IBRA regions	Supporting data	Australian Government Department of the Environment	Interim biogeographic regionalisation for Australia, landscape classification	na	na
Coastline	Supporting data	Geoscience Australia GEODATA TOPO 250K Series 3	Useful for spatial location and determining distances to/from coast	na	na

2.6. Means-to-end diagram for current and future threats

The means-to-end diagram illustrated in Figure 2 shows the main objective and the types of data that were used to meet the objective. Comprehensive primary data that reflects species ecology is crucial to a meaningful outcome. The data were combined in the MCAS-S example to explore spatial variability in potential refuges from predation and climate change for swift parrot nesting-habitat in Tasmania.

For other projects, we strongly recommend developing a means-to-end diagram prior to getting data into MCAS-S. This will ensure that the model structure is appropriate to the project aims and for the required data to be identified, formatted and entered into the datapack. Each MCAS-S layer can be exported to a GIS such as ArcGIS or Google Earth™ or saved as an image.

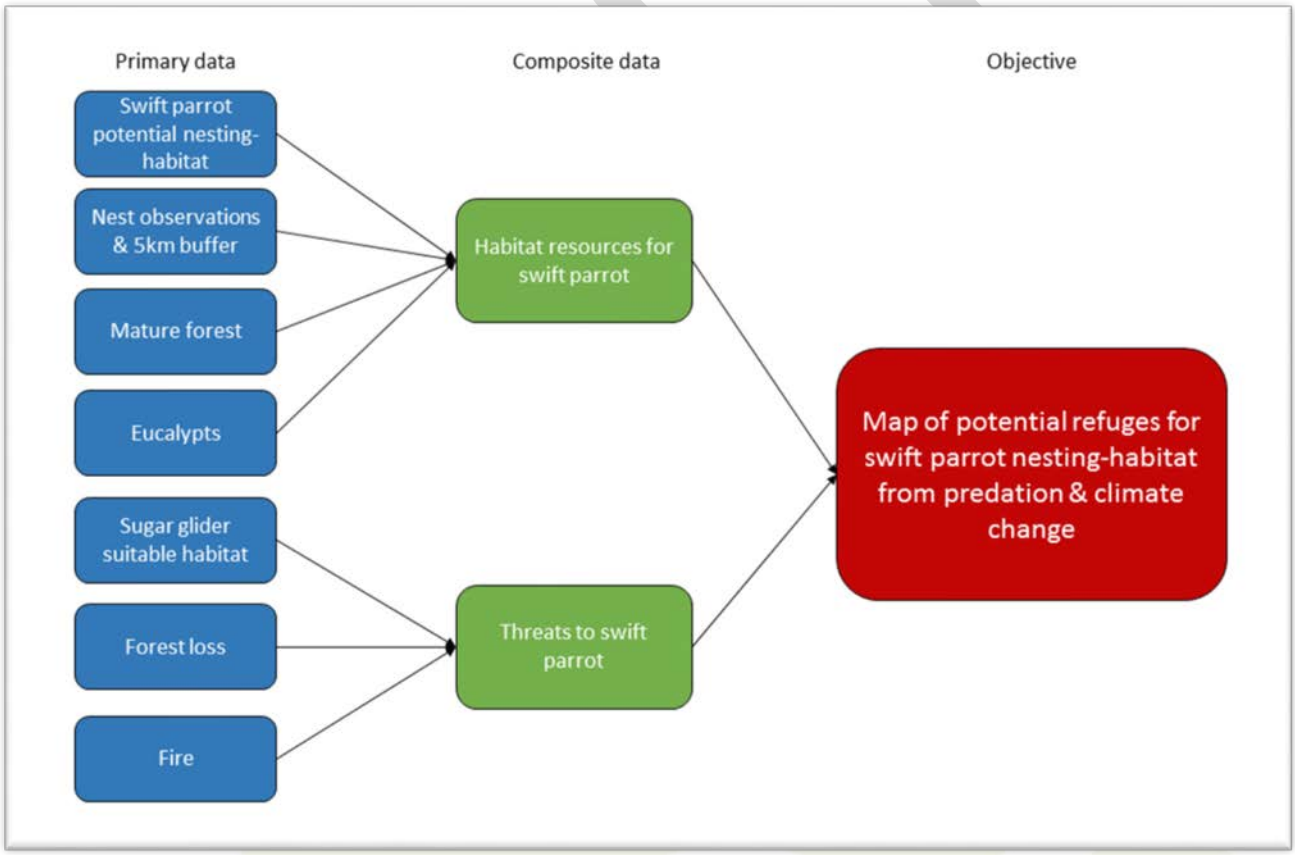

Figure 2: Means-to-end diagram to obtain the map of potential refuges or sanctuaries for swift parrot nesting-habitat from predation and climate change. Boxes on the left represent primary input layers and all other boxes represent different levels of spatial integration. The red box represents the final composite product that meets the original objective.

2.7. MCAS-S package structure

The swift parrot nesting-habitat MCAS-S datapack consists of two MCAS-S project files and a set of three MCAS-S data folders. The project files are:

MCASS_swift_parrot_tutorial.mcas contains the completed worked example described in this document.

MCASS_swift_parrot_tutorial_blank.mcas contains links to the data used in the worked example but the workspace is blank so that users can select and combine the layers from scratch.

The three data folders are Data, History and KML (see Table 2). The 'Data' folder contains all of the base data layers necessary for the swift parrot nesting-habitat analysis. The 'Data' folder includes four sub-folders: Primary, Classified, Overlay and Mask. Most of the base data layers for this analysis are located in the Primary sub-folder. We have also added some useful overlays and masks to their respective sub-folders. Some folders are initially empty but these should not be deleted as MCAS-S will write to these folders for various operations.

Table 2: MCAS-S folder structure and descriptions (adapted from MCAS-S user-guide V3.1 2014)

Level 1	Level 2	Description
Data	Primary	Gridded base layers each habitat resource or threat
	Classified	Gridded data exported from MCAS-S by user (initially empty)
	Overlay	Line or point data used for visual reference only: Tasmania boundary
	Mask	Gridded data used to restrict the area of analysis: The extent of Tasmania
History		Cached project files (initially empty)
KML		GoogleEarth™ (*.kml) files exported from MCAS-S (initially empty)

3. Worked example instructions

To gain the most from the worked example, open the MCAS-S file in your unzipped folder, and follow what we do in the text by having a play on the MCAS-S screen.

Open the file: MCASS_swift_parrot_tutorial.mcas

3.1. Primary input data

The file MCASS_swift_parrot_tutorial.mcas contains a worked example using most of the primary input datasets provided in the swift parrot nesting-habitat datapack (Figure 3). This worked example is based on the model structure shown in the means-to-end diagram in Figure 2.

The primary input layers are the smallest maps shown and each has three categories: 'NoData' within Tasmania (light grey); 'NoData' areas outside Tasmania (eg the ocean) are displayed as transparent. Areas that meet the conditions associated with a particular layer are shown in colour and may have a single value (eg swift parrot current nesting habitat layer) or have a single to multiple classes (categorical data, eg the Tasmanian Reserve System layers can be combined into one layer showing private and public reserves).

To zoom into a layer you have three options: change the interface magnification (first option on map menu bar above the right-hand side workspace, double click on a map (Esc to exit), or right click and then select 'Show in Google Earth'. Familiarise yourself with the different input layers by clicking on each individually and then viewing properties of the data in the left-hand information panel. At this point it would also be useful to review the information about the different input layers in Table 1.

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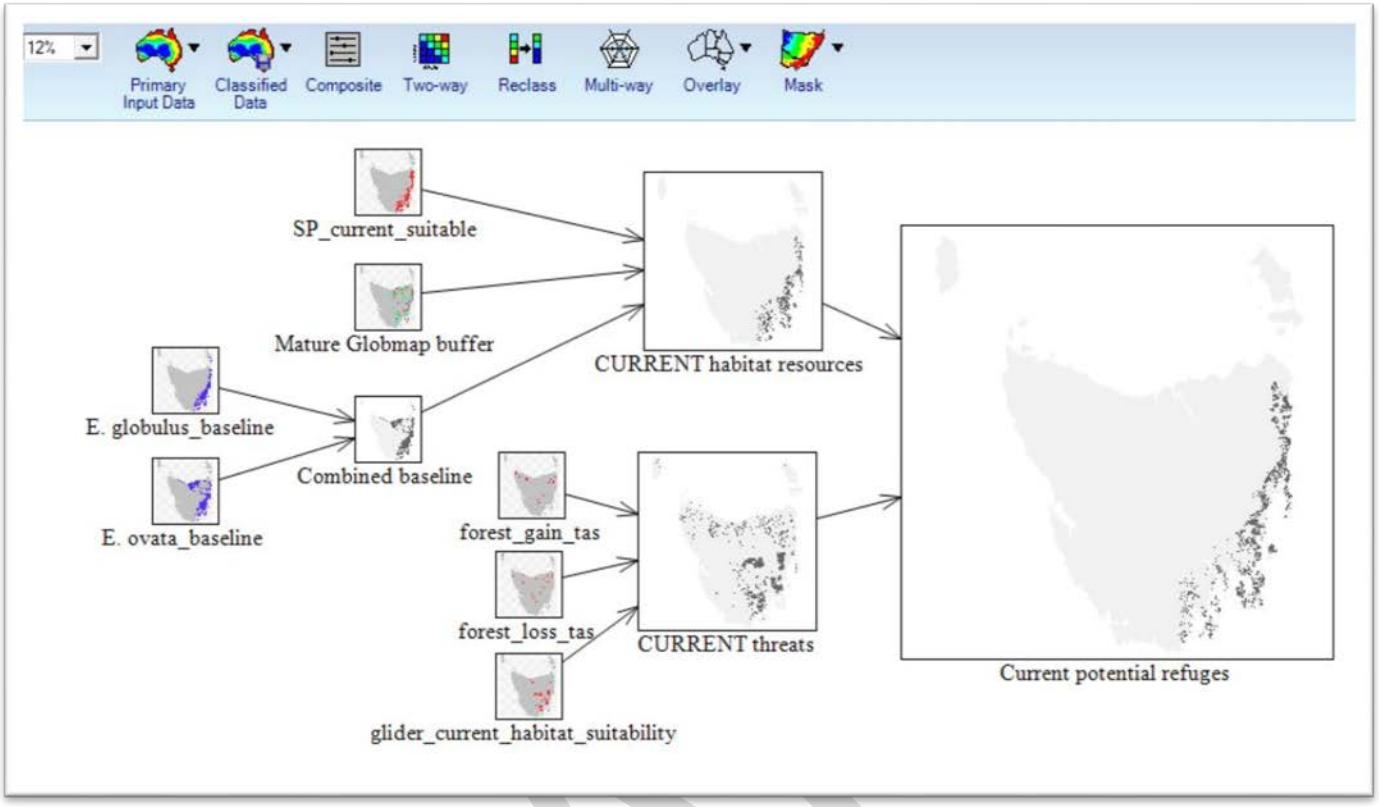

Figure 3: Structure of the swift parrot current nesting-habitat MCAS-S model. Colour indicates areas that meet nesting habitat or threat values (Table 1). Composite layers are monochrome with dark grey indicating areas that meet the criteria. The final composite shows areas that are currently suitable for nesting-habitat and are comparatively 'free' of threat.

3.2. Composite data

Any output that combines data from more than one layer is a composite or integrated layer. There are several options within MCAS-S for integrating layers. Details for how to alter these options can be found in the MCAS-S User Guide (2014 – Section 6: Explore and Combine data).

In this worked example a very simple rule set is used to integrate all of the data layers into three composites for 'current' data:

1. Current habitat resources for swift parrot
2. Current threats to swift parrot
3. Current potential refuges from predation

Using the 'Multi-way' from MCAS-S, the composite data called 'Current habitat resources for swift parrot' (Figure 4) shows areas that are:

- Covered by 'mature forests' (all of the 3 categories);

- 'nest observations with 5km buffer' zone; and
- values > 0.5 from the 'Swift parrot potential nesting-habitat' layer habitat suitability map using current climate data (the BIOMOD outcome).

In a similar fashion, the second composite data layer 'Current threats to swift parrot' is created using the Multi-way tool, selecting:

- 'Sugar glider current suitable habitat';
- 'Forest loss' ; and
- 'Forest gain'.

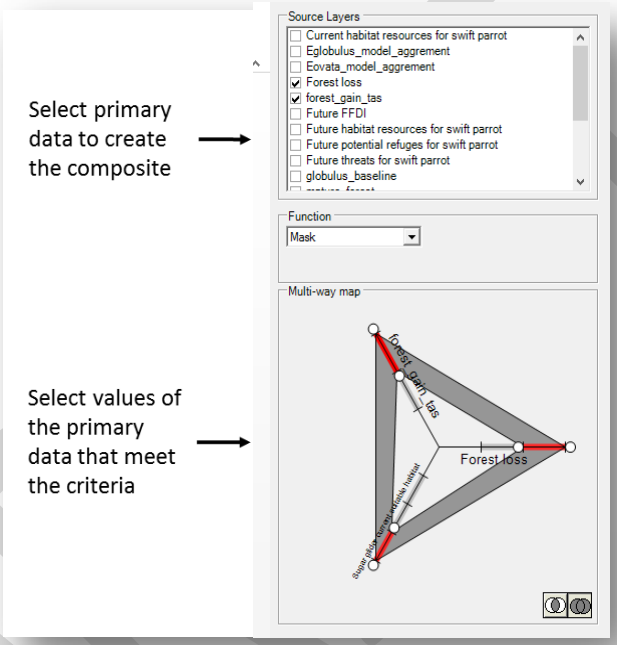

Figure 4: Example of the MCAS-S Multi-way tool to generate a composite data layer

To view or modify how layers have been integrated, click on the composite layer and view/change information in the information panel. Within MCAS-S, a mouse hover over a pixel of interest on a composite layer will result in the viewer window displaying the names and pixel values for each of the input layers that influence the selected integrated map (Figure 5). If viewer window is not visible, go to Edit>show viewer.

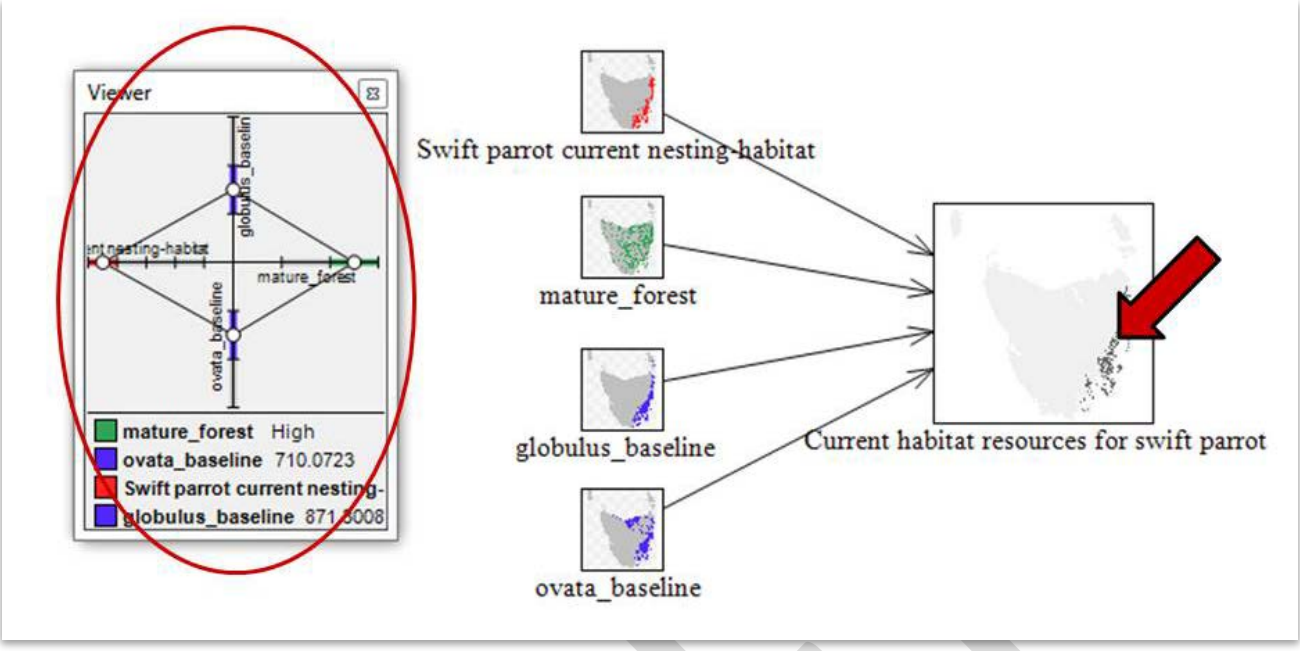

Figure 5: Viewer window in MCAS-S showing values of a pixel in the 'Current habitat resources for swift parrot' composite layer

When the current habitat resources and current threats composites are combined into the final composite, areas containing potential refuges from predation are highlighted. In this case we want to include the dark grey pixels from the layer 'Swift parrot current nesting-habitat' that DO NOT co-occur with the dark pixels from the 'Current threats to swift parrot'. This is achieved by using the Multi-way tool and checked the dark grey pixels from the habitat maps (that for some reason appear in RED in the display), and the light grey pixels from the threats map (that appear in BLUE in the display) (Figure 6).

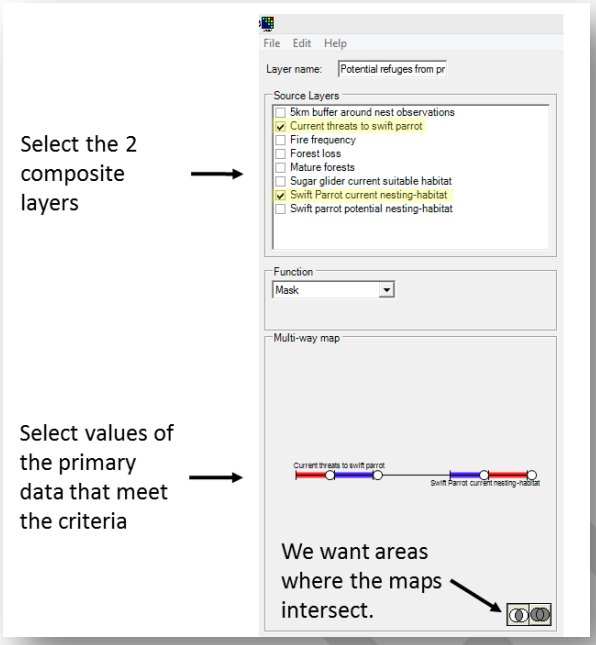

Figure 6: Example of the MCAS-S Multi-way tool to generate final 'objective' layer

A likely modification to this worked example would be to change the 'multi-way' maps to 'composite' maps, to allow weightings to be added for individual primary data layers. For example, some threats may be more 'important' in terms of their negative impacts on the swift parrot nesting-habitat than others, so they could be ranked in MCAS-S based on expert knowledge. More information about how to add weightings to composite layers can be found in the MCAS-S user guide (MCAS-S development partnership, 2014).

We compiled other relevant primary data that can be used in this exercise. For example, add into the MCAS-S panel the maps of private and public reserves (listed in Table 1), combine them into a single map called 'reserves', then combine that map with the 'Potential refuges from predation' to see areas that are already under the reserve system (Figure 7). Another option is to use the new 'reserve' map for reporting, in that case the layer should be exported (automatically saved in the 'Classified' folder) and then transferred to the 'Mask' folder.

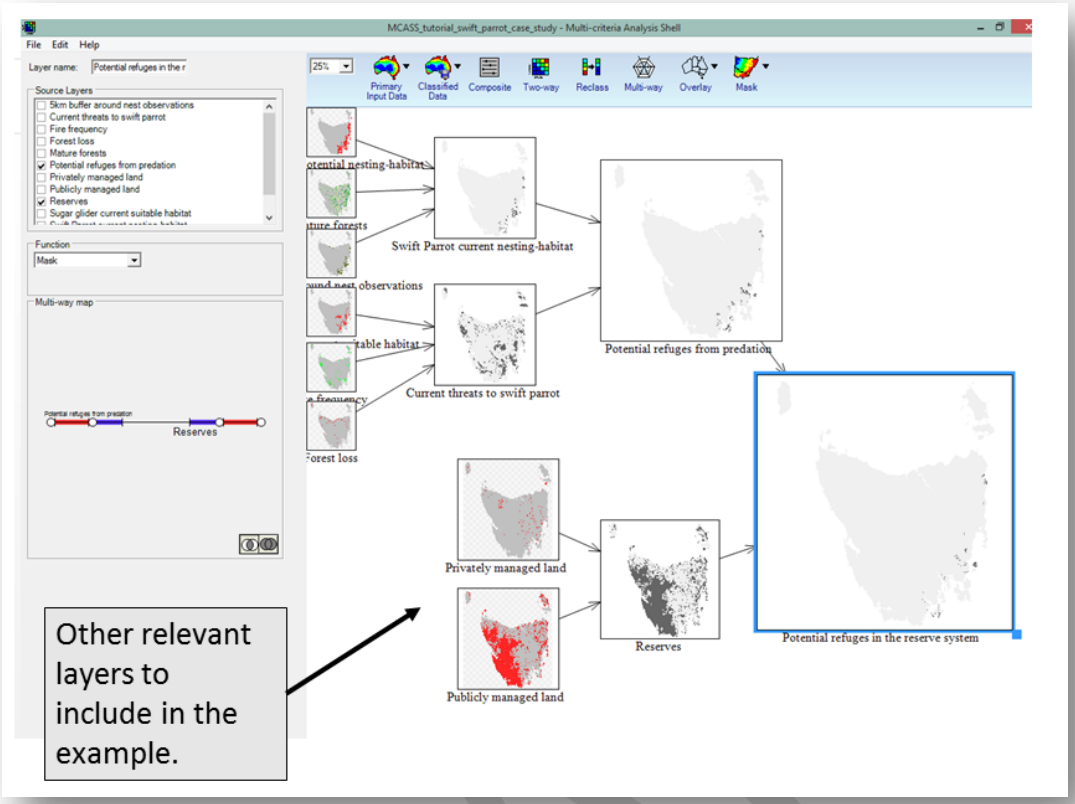

Figure 7: A snapshot of the MCAS-S example when reserve layers are incorporated

For our climate change example, another simple rule set is used to integrate all of the data layers into two future composites: future habitat resources and future threats to swift parrot (see Figure 8).

Using the 'Multi-way' from MCAS-S, the composite data called 'Future habitat resources for swift parrot' shows areas that are:

- covered by mature forests (assuming that if not affected by land use change, mature forest should provide the same habitat resources by the end of the century);
- 'nest observations with 5km buffer' zone; and
- 'Swift parrot future nesting-habitat', model agreement layer calculated using the future climate projections by 2080 (the BIOMOD outcome, see Table 1).

In a similar fashion, the second composite data layer 'Future threats to swift parrot', is created using the Multi-way tool, selecting:

- 'Sugar glider future suitable habitat' and;
- 'FFDI'

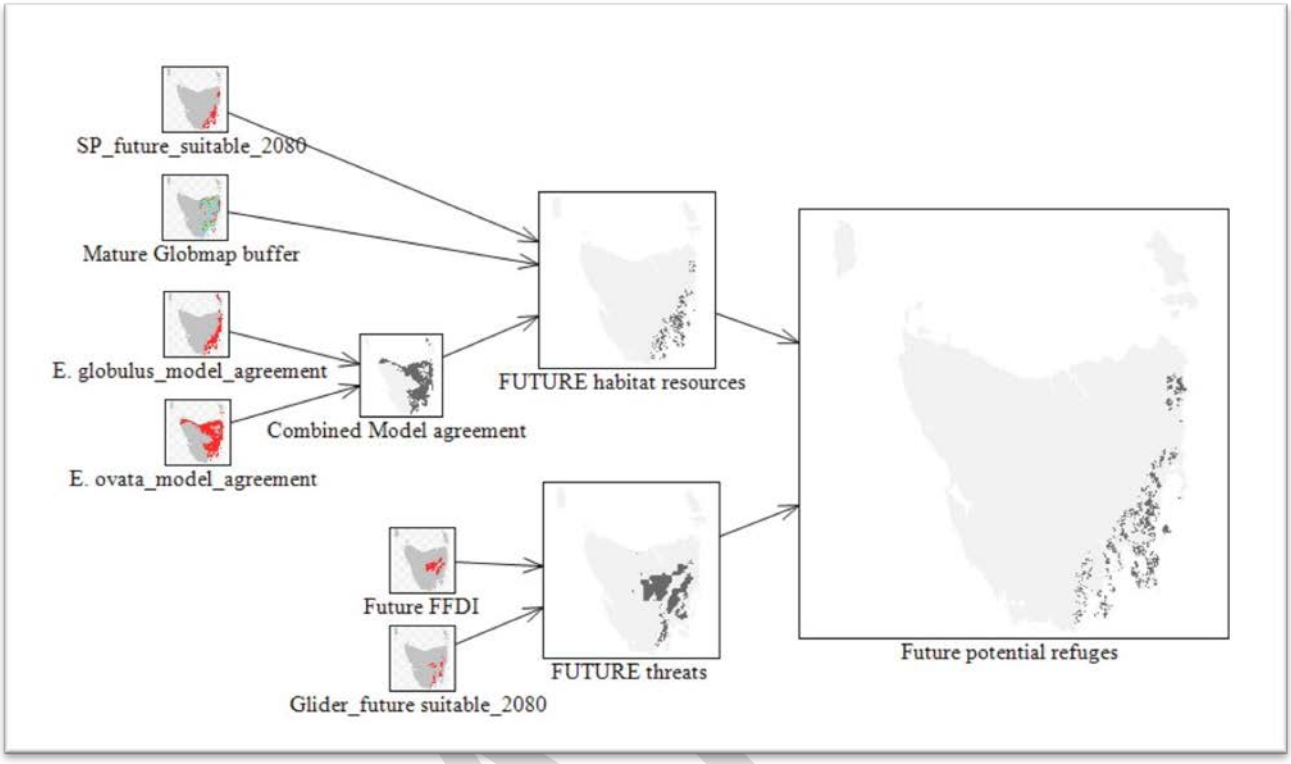

Figure 8: Future refuges from predation and climate change

The current and future potential refuges for swift parrots can be compared on-screen and then combined into a single map showing areas that are currently deemed to be refuges and are projected to remain as refuges by the end of the century (Figure 9).

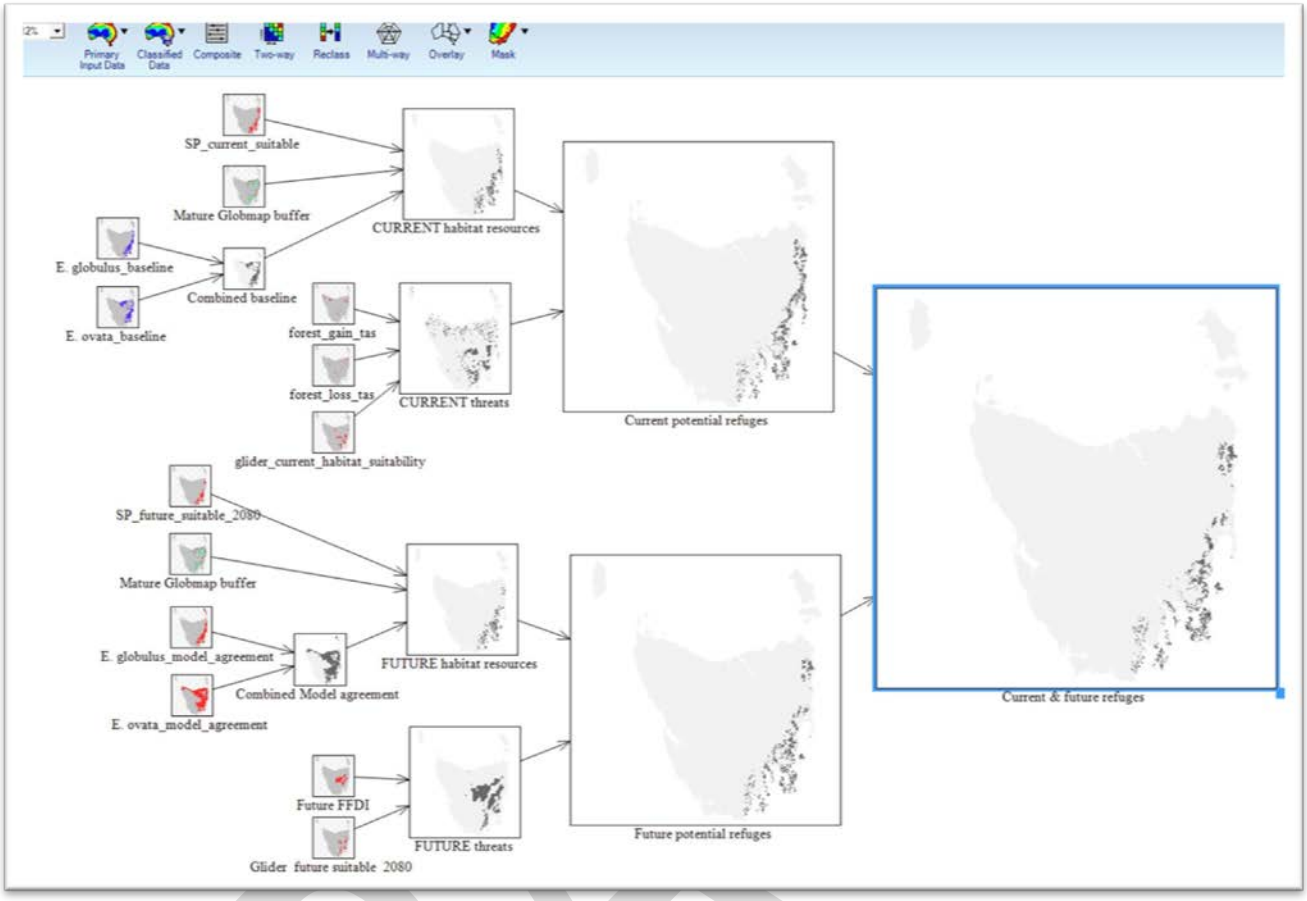

Figure 9: Current and future potential refuges from predation and climate change for swift parrots

3.3. Modifying primary and composite data layers

Clicking on any layer within the worked example will show details about the layer in the left-hand information panel. Many of the options within this panel can be altered including the layer name, colour scheme, the number and colour of classes and the names of the categories or classes within each layer.

Other ways of modifying results are to:

- Delete layers - Right click, then delete. Note you cannot undo a delete! You'll need to drag the map back in from the Primary Input Data tab if you make an error.
- Change the input layers for an existing composite data layer - Modify connections by changing the input layers on the information panel or by modifying how the layers are integrated (e.g. by creating a 'Composite' map using this option on the Map menu bar (instead of a Two-Way or 'Multi-Way) and selecting and completing either 'Manual', 'Function' or 'AHP weighting' options to combine layers.

- Add layers from the primary folder - Click and drag layers from the 'Primary Input Data' tab.

- Create new integrated layers - Click and drag from either the 'Composite', 'Two-Way', 'Reclass' or 'Multi-Way' tabs to create a new blank map. Create connections by selecting input layers on the Information Panel. See the MCAS-S user guide for more information about these tools.

3.4. Overlays and masks

The swift parrot nesting-habitat datapack contains some overlay and mask files, including:

- IBRA regions
- reserves

Overlays added to the maps are displayed on screen primarily as a useful visual reference, as they do not influence any of the calculations occurring in the model. Any line or point data can be added to the overlay folder and viewed in MCAS-S, however it is important that the projection of this data matches the projection of the raster layers in our datapack.

In comparison, masks can be used to analyse data within a specific area. For example, using the 'IBRA region' mask, select 'TSE' (Tasmanian South East). All maps will be zoomed to that region and any further analyses will only be undertaken for the selected area. To add/remove a mask, select the 'Mask' tab on the Map menu bar and then check/uncheck the relevant box.

3.5. Reporting

MCAS-S gives the option to generate reports using the 'Reporting' tool. The reports give, for example, the total number of hectares in a selected region where the criteria are met. In this example we can determine the total number of hectares that are considered as potential refuge from predation. To compile a report, right click on top of the map you are interested in and select reporting. The Reporting window will appear (see Figure 10) and there you can select the reporting region, in our example we will use 'Tasmania'. For the 'type' of report (Report as), we will use cell counts because our pixels are 100x100 m, so 1 pixel = 1 hectare. All layers in this example have the same resolution, so any layer can be chosen and the outcome should be the same. If you chose to report by land tenure, a table will appear with a list of the reserve names. In this example we chose to report for the whole of Tasmania, so total the number of cells that met the criteria are shown as a single row in the report (Figure 11).

Reports can be saved as *.csv files and opened in a spreadsheet program for further analysis and data manipulation.

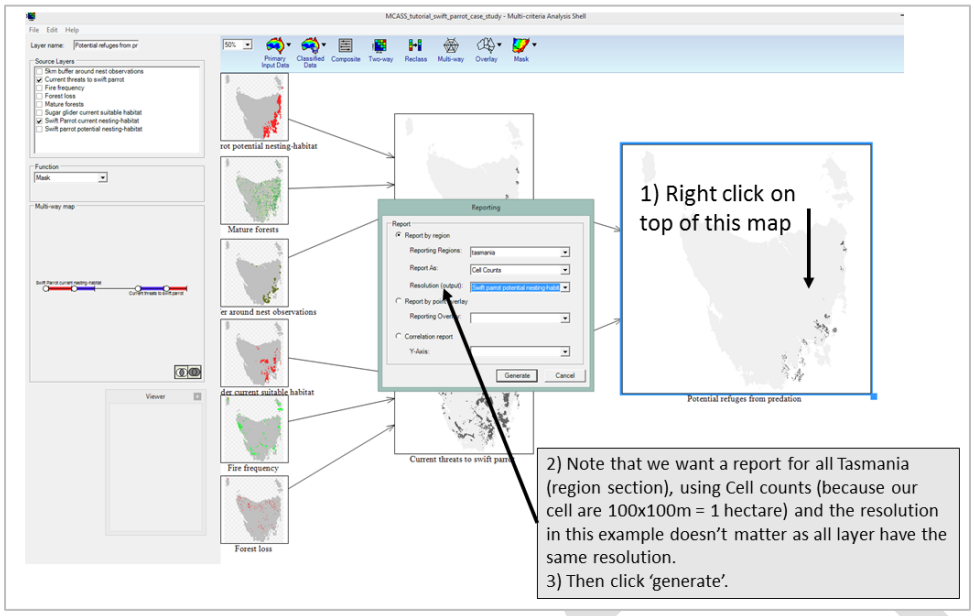
1) Right click on top of this map
2) Note that we want a report for all Tasmania (region section), using Cell counts (because our cell are 100x100m = 1 hectare) and the resolution in this example doesn't matter as all layer have the same resolution.
3) Then click 'generate'.
Potential refuges from predation
Mature forests
Fire frequency
Forest loss

Figure 10: How to generate a report in MCAS-S

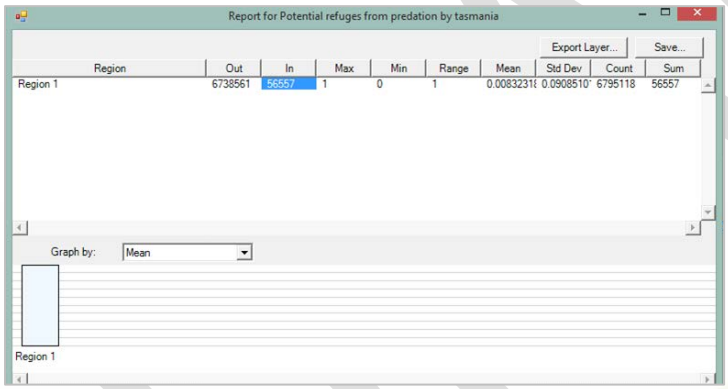

Figure 11: MCAS-S sample report

3.6. Viewing results outside of MCAS-S

MCAS-S allows users to export layers for use in other applications. The available options for exporting are accessed via a right-click on the layer of interest and include:

1. Show in Google Earth: Note at time of publication there was a maximum resolution (1000*1000 cells) for viewing MCAS-S layers in Google Earth™. Google Earth™ will render a lower resolution version that may not adequately represent fine scale data. To view files at the full resolution in Google Earth™ the user must export the layer from MCAS-S (see 3 below) and convert to *.kml in an alternative application such as ArcGIS.

2. Save image: Allows you to save the map, legend and/or histogram of the layer of interest.
3. Export: Creates a GEOTIFF or ASCII file of the layer and saves it to the Data\Classified. This procedure requires the creation of a small metadata file known in MCAS-S as a tip file. See Appendix 10.2 for details on completing a tip file metadata record.

3.7. Management conclusions from the worked example

This exercise highlighted areas that may currently act as refuge from predation for swift parrot nesting-habitat. About 31% of that area is already under the Tasmanian reserve system, and the remaining locations may be interpreted as priority areas for conservation (Figures 3 and 7).

Our models project an approximate 23% reduction in climatically suitable area for swift parrot nesting-habitat by 2080, predominantly along the north-east coast of Tasmania. However, it is important to note that not all projected potential nesting-habitat is necessarily available for nesting. Some areas may be climatically suitable but may not support mature forest. When we filtered our projections of future nesting habitat using existing data on extant mature forest cover across the study area - assuming that these forest will persist - the availability of potential habitat decreased by approximately 50%.

We need to emphasise that these results are based on the primary data we used in the analysis. Including new or revised data is likely to change the results. However, our main objective was to demonstrate how the MCAS-S tool can assist with determining management priorities for the natural habitat of the swift parrot and to consider the interaction between multiple variables.

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4. Appendix

Technical recommendations	
Extent	All layers to be used in MCAS-S should have the same extent. In this case the extent for Tasmania is: Top: 5626000; Left: 220000; Right: 628000; Bottom: 5163000
Resolution	Layers to be used in MCAS-S can have different resolutions; however, we recommend using the same resolution, in particular for beginners. The resolution we used is 100 x 100 metre pixels, so, 1 pixel = 1 hectare.
Projection	All layers **must** have the same projection. We reached an agreement with DPIPWE to use GDA94 Zone 55 South. This ensures all pixels (from north to south) are comparable in terms of area.
NoData	No data values within Tasmania were given a value of -888
Ocean NoData	No data values outside Tasmania, in the ocean, were given a value of -9999. This is the number MCAS-S understands as NoData, so it will be displayed transparent.

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